An Innovative Coastal-Ocean Observing Network (ICON)

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LONG-TERM GOALS

The Innovative Coastal-Ocean Observing Network (ICON) is a partnership of government, academic, and industrial entities funded by the National Ocean Partnership Program (NOPP). Its goal is to bring together modern measurement technologies, to develop new technologies, and to integrate them within a data assimilating coastal ocean circulation model.

OBJECTIVES

The objectives of the project are to evaluate the several real-time observing systems as components of future coastal monitoring networks as well as sources for data-assimilating numerical models.

APPROACH

The approach taken in this project is to build on existing partnerships and observing systems around the Monterey Bay region by providing coordination, additional instrumentation, and a focus on evaluating the impact of the various measurements on the validation and forcing of a coastal circulation model. The region of interest and the primary observing systems are outlined in Figure 1. The major components of the observing network include 1) surface current maps from shore-based high frequency (HF) radar installations, 2) subsurface currents, temperature, salinity, and bio-optical properties plus surface meteorological properties from four deep-ocean moorings, 3) sea surface temperature and color from satellites, and 4) along-track temperature and temperature variances from two acoustic tomography slices through the region. These data sets each involve real-time data telemetry. The data themselves are being interpreted and displayed on the central web site. They are also being used as either validation or assimilation sources for a nested, primitive equation numerical model designed to track the evolution of mesoscale filaments and eddies related to coastal upwelling.

WORK COMPLETED

A great deal of work has been completed during this first year of the ICON project, including the construction and deployment of the M4 mooring, overseen by S. Ramp, with a unique suite of bio-optical sensors developed by R. Maffione and HOBI Labs, in addition to the many other measurement and communication systems. The mooring is shown during deployment in Figure 2. Construction of a new Multi-frequency Coastal Radar (MCR) has been completed by J. Vesecky. That system will be deployed south of Monterey and, using help from D. Barrick, paired with a CODAR-SeaSonde HF radar system at Pt. Sur pending final site approval. Several hydrographic cruises led by C. Collins have been carried out along the tomography lines and a successful solution to the forward problem for acoustic transmissions along the Davidson Seamount path has been overseen by C. Chiu and written up in the M.S. thesis of J. Onofre. The nested circulation model has been configured, spun-up, and shown to produce realistic mesoscale upwelling features by I. Shulman. It is now being used with twin experiments as part of the development of data assimilation schemes that will use surface current fields from the HF radar network.
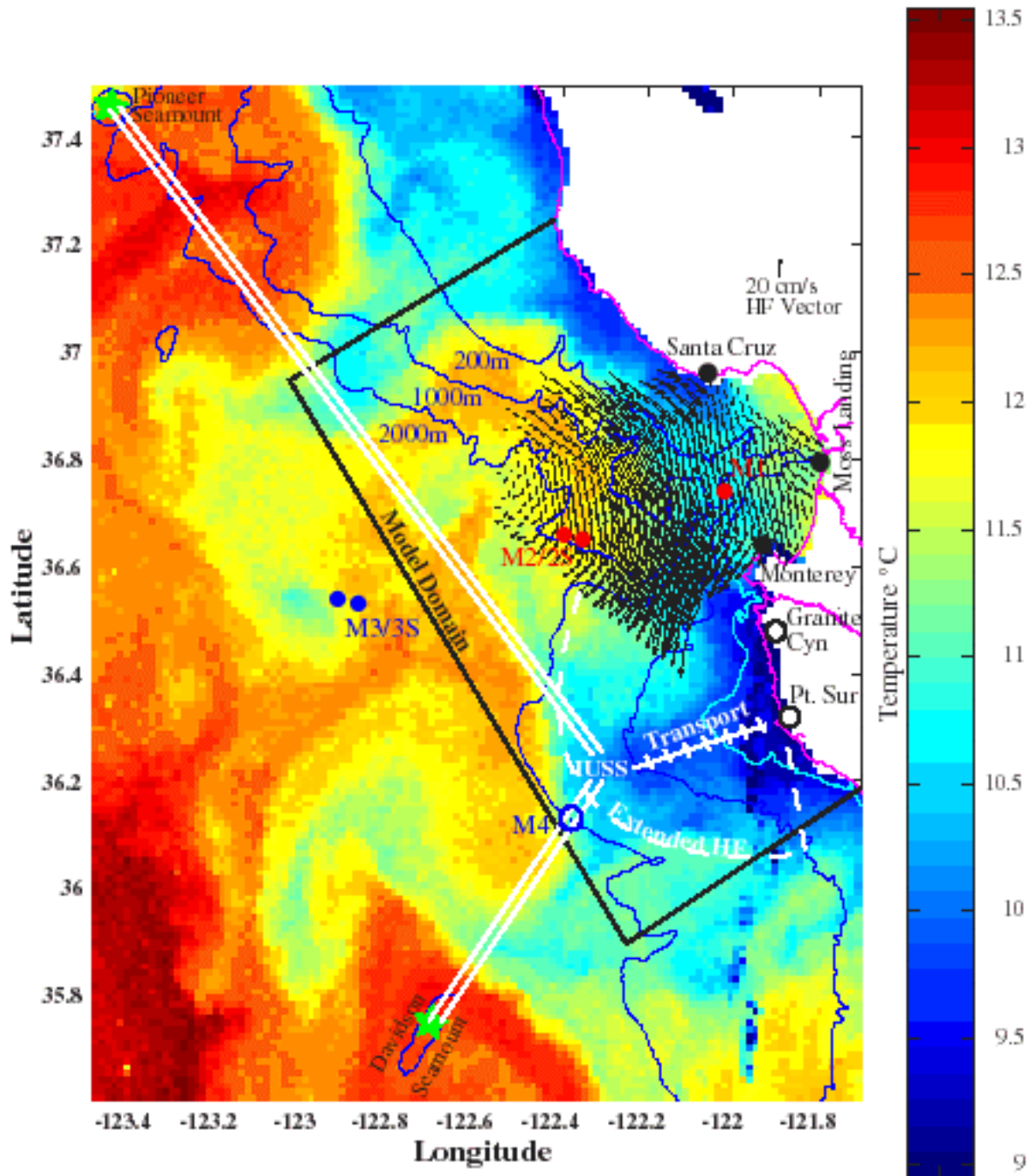
1. ICON observing systems and modeling domain with SST patterns from 3 Nov. 1994. Daily averaged surface current vectors from the three-site HF radar network around Monterey Bay (•) are shown along with the extended coverage area (---) from new sites to the south (○). Real-time acoustic tomography sections are available from Davidson and Pioneer Seamounts via hydrophones cabled to shore (IUSS). Meteorological and oceanographic data are telemetered to shore from moorings M1, M2, M3 and M4, including advanced bio-optical sensors on the new M4 mooring.

2. M4 mooring during deployment on 24 August 1999. Among the many sensors visible are the HOBI Labs bio-optical sensors just below the float and the sonic anemometer at the very top of the tower. Not visible are the ADCP and eleven microCAT temperature and salinity probes.

RESULTS

Results have been spread across the many components of the project with emphasis on initial data processing and quality control. One example of a historical problem that was uncovered and mitigated by L. Rosenfeld relates to wave contamination of downward-looking ADCPs on surface-moorings. She has optimized the ADCP sampling scheme, given the limitations on power, for all four moorings. This involved eliminating use of the tilt sensors and pinging more frequently over longer ensembles. On the newest mooring, M4, an improved sonic anemometer system is being used and a brand new suite of bio-optical sensors is in place (Figure 2). One of the many optical parameters returning from M4 is the spectral irradiance data from the HOBI Labs HydroRad, a sample of which is shown in Figure 3. On the M1 mooring, F. Chavez of MBARI has deployed a prototype "Long Ranger" ADCP, which is providing real-time current profiles down to 500m (
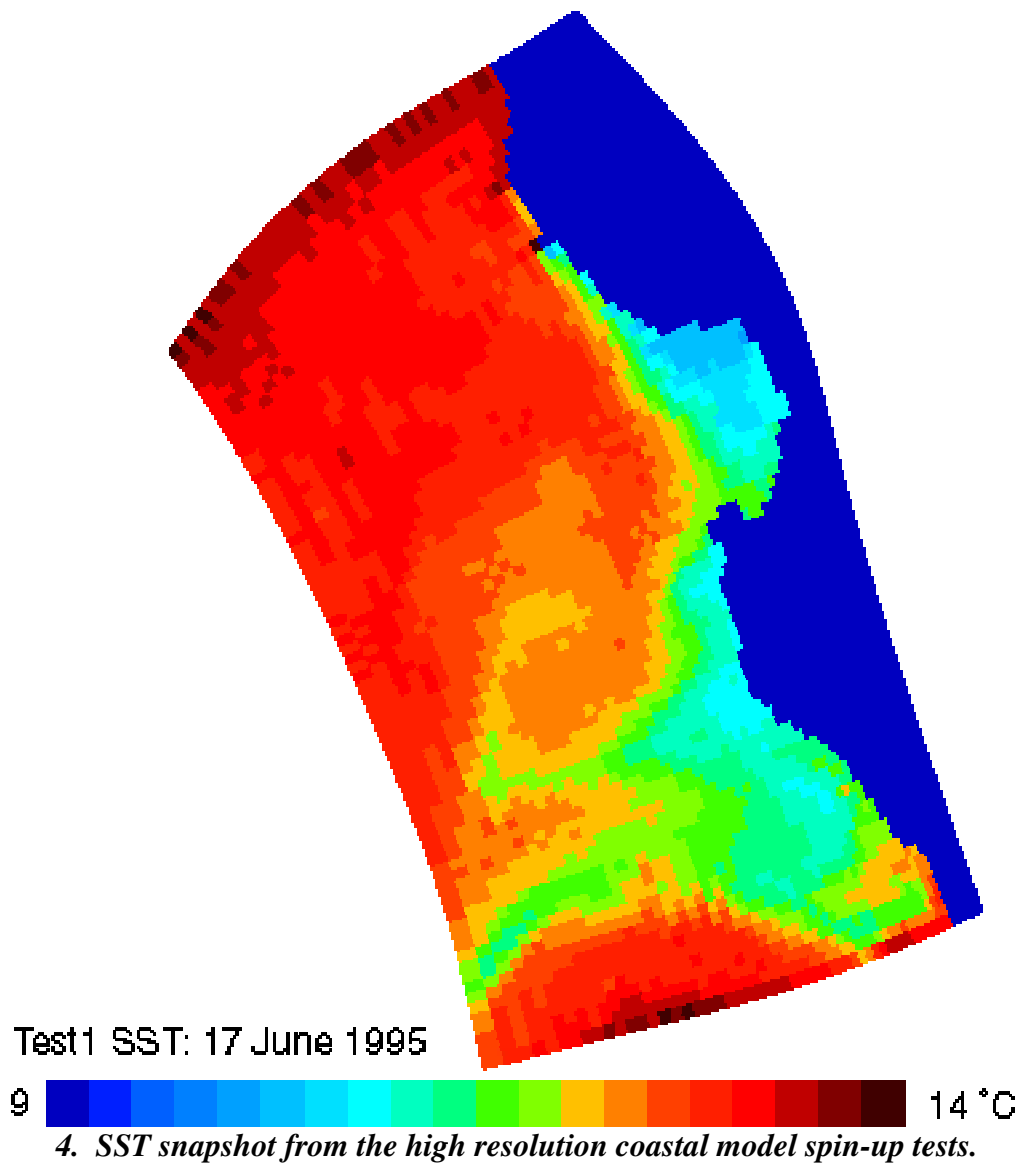http://www.oc.nps.navy.mil/~icon/moorings/).

Results from the HF radar network include processing and archival of data from the CODAR-SeaSonde instruments back to July 1994 overseen by J. Paduan. Monthly averaged currents, variability, and spatial correlation scales have been computed over 30 separate months. These latter statistics are being used in surface velocity smoothing and filtering operations, which are needed in order to use the radar-derived data in assimilation schemes. Algorithm development for the HF radar systems themselves has also taken place. Using MCR data, D. Fernandez has tested schemes to continuously calibrate relative antenna phases, which are critical to accurate velocity mapping. MCR data is also being used, together with surface wave data from the NPS Flux Buoy, to investigate the effect of Stokes Drift on radar-derived surface currents.
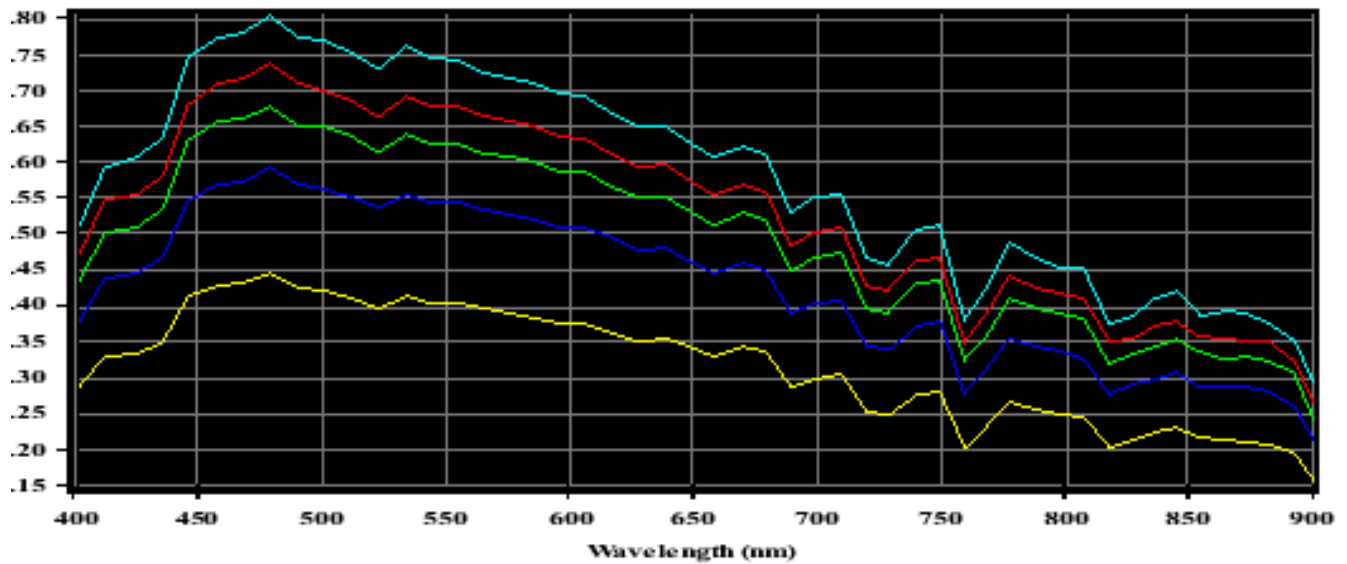
3. Spectral Solar Irradiance, E_d (W m^{-2} nm^{-1}), throughout the day from the HOBI Labs HydroRad on mooring M4.

Central to this project is the modeling work of I. Shulman. He has conducted tests on the high resolution coastal model using NOGAPS wind forcing during the 1995 upwelling season. Nesting of this model within a regional-scale model run by J. Kindle has been implemented and optimized. A single SST image from one of the spin-up runs is shown in Figure 4 illustrating the model domain and the realistic upwelling responses seen north and south of Monterey Bay. The model is now being run with twin experiments designed to test data assimilation schemes. These results have been written up for the Sixth International Conference on Estuarine and Coastal Modeling to be held in New Orleans, November 1999. The next modeling phase will shift the focus to the 1999-2000 time frame, and it will include assimilation of surface current information and validation against subsurface temperature and velocity information from the moorings and the acoustic tomography transects. Wind forcing will also shift to output from a high resolution reanalysis from the Navy's COAMPS model through an established collaboration with NRL.

The two local acoustic tomography sections that are being monitored as part of this project represent a unique opportunity to validate the nested coastal circulation model, particularly when it comes to evaluating the integral effect of assimilating surface current information. The acoustic ray paths sample the entire water column and provide both statistical and deterministic information about temperature variations through the forward and inverse tomography problems, respectively. Hydrographic surveys have been conducted this year along both slices. Extensive work has been completed on the forward problem along the path to Davidson Seamount (Figure 1). The modeled ray paths and the spectrum of arrival time variations observed over a six month period are shown in Figure 5. The distinct signature of the arrival time variations, along with the temperature variations that they derive from, provide an integral measure of the mesoscale variability within the model domain. The model temperature variances will be sampled (with and without data assimilation) along these ray paths in order to validate these model statistics against the acoustic observations. A second check will be performed using ray paths emanating from Pioneer Seamount.

Test1 SST: 17 June 1995

9   14 °C

4. SST snapshot from the high resolution coastal model spin-up tests.

IMPACT/APPLICATIONS

The likely impacts of this project include improved real-time communication, processing, and display of coastal ocean data along with improved algorithms for assimilating that data into numerical models.

TRANSITIONS

The transition opportunities are related to improved coastal nowcast and forecast systems.

RELATED PROJECTS

This project is closely related to other NOPP efforts focusing on data assimilation and coastal ocean modeling. The ONR-sponsored project of Paduan and Ly to observe and model surface waves in Monterey Bay is a direct extension of the ICON efforts that will improve, among other things, the assimilation of surface currents from HF radar data.
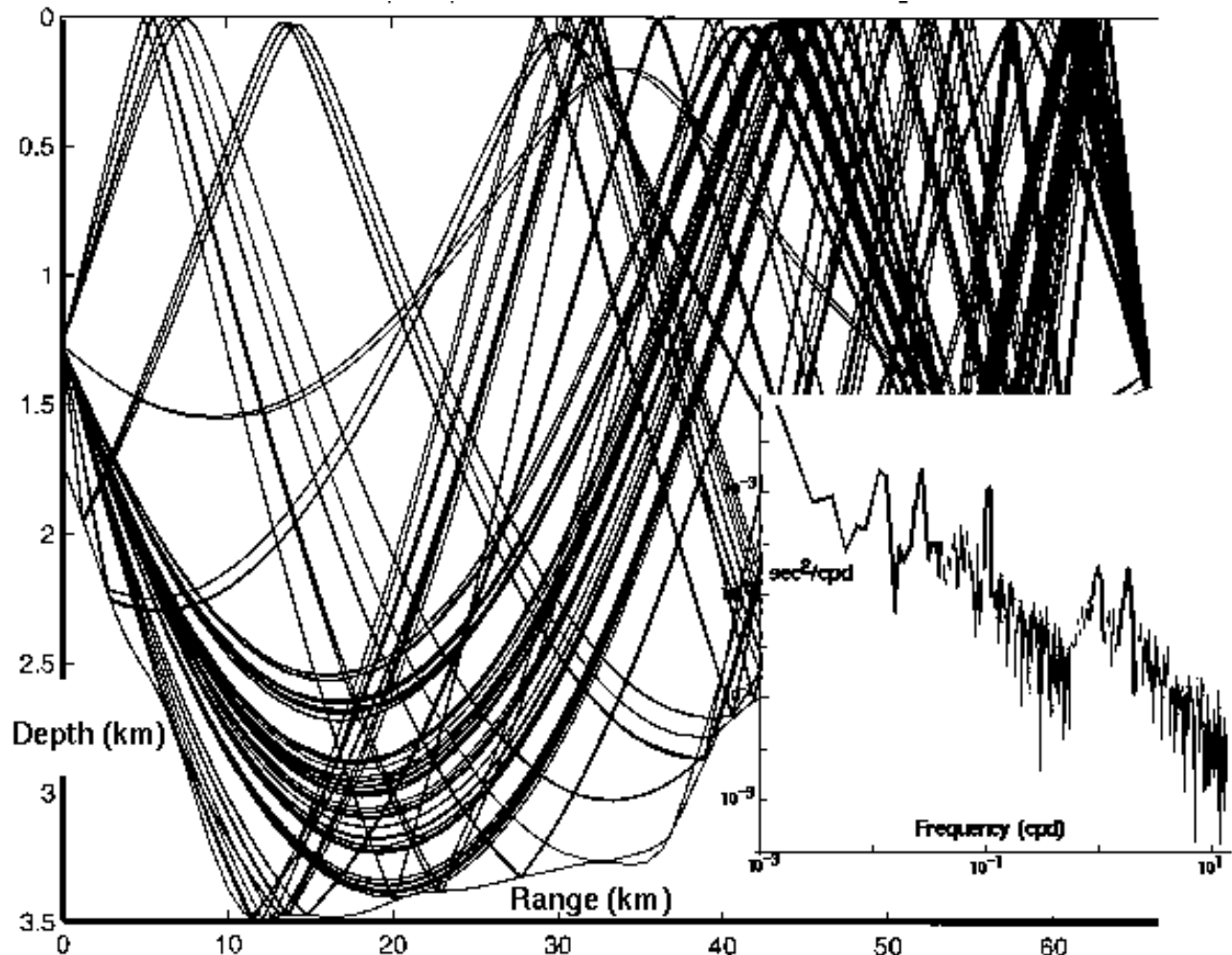
5. Modeled acoustic ray paths along the tomographic section to Davidson Seamount and spectrum of observed travel times (inset) for one of the arrival groups over a six-month data set showing energy peaks with periods of 12 hr, 24 hr, 8 day, 18 day, and 26 day.

PUBLICATIONS

Paduan, J.D., L.K. Rosenfeld, S.R. Ramp, F. Chavez, C.S. Chiu, and C.A. Collins, 1999: Development and maintenance of the ICON observing system in Monterey Bay. Proceedings, Third Conference on Coastal Atmospheric and Oceanic Prediction and Processes, New Orleans, LA, 3-5 November.

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